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Energy research and technology development data collection strategies: The case of Greece

Haris Doukas [a], Alexandra G. Papadopoulou [a,*], Christos Nychtis [a], John Psarras [a], Nicole van Beeck [b]

[a] National Technical University of Athens, School of Electrical and Computer Engineering, Decision Support Systems Lab (EPU-NTUA), 9 Iroon Polytechniou Street, 15773 Athens, Greece

[b] SenterNovem, 21 Swentiboldstraat Street, Sittard, The Netherlands

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Abstract

The European Union (EU) from the beginning of 2007 has focused its emphasis on the development of a new policy that puts energy back at the heart of EU action. Indeed, it has very often been stated that the difficulty and complexity of achieving green energy targets in the EU will require strengthened measures to promote implementation of new energy technologies (NET), as well as measures to support the related energy Research and Technology Development (R&TD). Often forgotten is the fact, that most of all, a European-wide co-ordinated forum is needed to continuously develop and sophisticate the monitoring and methodology results, bringing together specialised statisticians, energy researchers and experts on energy socio-economics. Today a nebulous picture prevails on the existence of categorized data with regards to energy Research and Technology Development (R&TD) expenditure. In this context, aim of this paper is the presentation of energy R&TD data collection strategies, as well as the related findings for the Greek energy market.

Keywords: New energy technologies; Research and Technology Development; Data collection strategies

Contents

1. Introduction

European energy strategy and policy is strongly driven by the twin objectives of sustainability (including environmental aspects) and security of supply. Implementation of NET are key

* Corresponding author. Tel.: +30 210 7722083/3583; fax: +30 210 7723550.
E-mail address: alexpapa@epu.ntua.gr (A.G. Papadopoulou).

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means of satisfying these objectives, such as renewable energy systems at the supply side and improved energy end-use efficiency (EEE) at the demand side [1].

Indeed, it has very often been stated that the difficulty and complexity of achieving green energy targets in the EU will require strengthened measures to promote implementation of NET, as well as measures to support the related energy Research and Technology Development (R&TD) [2,3]. Often forgotten is the fact, that most of all, a European-wide co-ordinated forum is needed to continuously develop and sophisticate the monitoring and methodology results, bringing together specialised statisticians, energy researchers and experts on energy socio-economics [4,5].

Moreover, the Commission's policy efforts such as the White Paper on Renewables, the Green Paper "Towards a European Strategy for the Security of Energy Supply" and directives such as Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources and Directive 2004/8/EC on the promotion of cogeneration, have pointed out the crucial need for improved EEE and the important role of data monitoring progress in that [6–9].

As clearly stated from the above, the existence of a "one-stop-shop" serving the policy and decision-makers of the enlarged EU with unbiased and more complete and validated R&TD expenditure data on green energy technologies is missing today. The most needed data concerns:

- NET technology key parameters, like energetic efficiencies and parameters influencing their life cycle impact;
- Greenhouse gas avoidance efficiencies (notably for alternative fuels);
- Natural resource potentials for renewable energy (RE);
- Technology dependent socio-economic parameters of the NET options, like investments, acceptability, etc.

The current paper emphasizes on the last category, namely expenditure data. Today only fragmented or inconsistently categorised expenditure data is available, which lacks verification via quality systems and is not yet suited for comparative integration. The lack of consistent historical data synopsis on all energy R&TD expenditure in the last decades (from the 1960s until today) has caused a very nebulous picture regarding the efficiency of different energy-technology expenditure-lines, especially when looking at their derived societal or economic benefits (wealth production, job creation, environmental relief, impact for sustainable development, etc). Indicatively, a number of difficulties are associated with energy data collection, such as the double counting, the lack of reliable data disaggregated into energy technologies and thus the existence of data exclusively in their aggregated form, the inconsistency in time series, the limited and sporadic release of R&TD expenditure data due to their strategic importance, as well as the absence of specific institutions authorized for the collection of private R&TD expenditure [10].

Taking into consideration the above cited situation, a Scientific Reference System (SRS) has been set up to enhance availability, quality and completeness of data on NET options. In a European research area (ERA) approach, the SRS joins IEA, EU-institutional, national and academic data-providers, and experts for energy technology, economy and policy research. Results will underpin future energy–economy–environment models and EU regulations with references, thus supporting sustainable energy policy and global climate change mitigation [11]. The "Scientific Reference System on New Energy Technologies, Energy End-use Efficiency and Energy R&TD (SRS NET & EEE)" project responds to the need of policy and decision-makers for a database with unbiased, validated, organized and scientifically agreed technical and economic information on renewable energy and end-use efficient energy technology. Moreover, comparisons with other clean energy technologies of comparable importance for sustainable development are realized. In order to underpin sustainable energy R&TD strategies, all energy technologies (including fossil, nuclear) are covered in the collecting procedure of all historical European energy R&TD expenditure data since the 1960s. SRS NET&EEE has the concrete objective to set up a co-ordination mechanism, which is capable to support, via validated data, the EU's coping with the challenges of its implemented policy goals.

The project's structure involves methodology for validation and data quality; technology data validation synopsis; energy R&TD expenditure data collection (public and private) and consensus building and diffusion for decision support. The procedure includes existing data collection methods as developed by significant data providers like the IEA, EUROSTAT, EEA, EC-JRC, National Energy Authorities and Scientific Authorities in the field, and then goes beyond the status quo and describes well advancements. Renewable energy and end-use efficient energy technology data are collected from existing statistical offices, international and national energy agencies. In addition, existing energy R&TD-expenditure data are collected in the enlarged EU. The consensus building and diffusion for decision support integrates, publishes and disseminates results from all the above activities via an open platform for stakeholders to feedback.

In that context, aim of this paper is the presentation of energy R&TD data collection strategies according to the methodological approach of the SRS project, as well as the related findings for the Greek energy market. Apart from the introduction, the paper is structured in three sections.

- Section 2 focuses on the methodological approach for harmonizing all the different R&TD data collection techniques, while the data collection strategies followed are depicted along with their strengths and weaknesses.
- In Section 3, the case of Greece is thoroughly examined giving the view for the adopted R&TD data collection procedures, taking into consideration the country's energy status, framework and market potential. Results of public and private R&TD data series are also presented for certain energy technologies from different kind of fields (RES, fossil fuels, end-use efficiency, etc.) as those have been defined in the SRS project.

- Lastly, the main conclusions drawn up from this paper are summarized in Section 4.

2. Energy R&TD expenditure data: collection strategies

All the available approaches adopted on R&TD data collection for NET need to be elaborated for the harmonization of the existing methodological approaches. In particular, the following activities taking part can be described as [12]:

- *Definitions* of the technology data categories in order to achieve a common understanding between statisticians, energy technology experts and energy socio-economists for the most important parameters of the related data assumptions.
- *Review* of the existing R&TD data collection methods, based on the experience from the common reporting rules from the international institutions, literature and from statistical databases (international, EU and national).
- *Comparisons* of previously mentioned methods that were used to gather the related data. The most important parameters of the previously analyzed methods are illustrated, identifying reporting structural gaps, such as the lack of data for certain regions, certain technologies and certain market segments or participants.
- *Recommendations* contributing in the harmonization of the set of data-collection categories, the aggregation levels and best practice definitions, thus, overcoming the inconsistencies by taking into consideration the current status in the national, European, as well as international level.

Through the experience gained in undertaking the R&TD data collection procedures, an incorporation of the difficulties faced was elaborated. In addition to this, particular emphasis has been laid on the strategies developed in order to overcome the occurred difficulties for achieving high quality data [13]. The data collection strategies used for gathering public and private energy R&TD expenditure data in different EU countries, including the New Member States include:

- Specific study or assessment;
- Financial data from collaborative R&TD program;
- Investigation of annual activity reports;
- Data about partial R&TD projects.

Particular information regarding each strategy is described in the following paragraphs.

2.1. Specific study or assessment

This strategy incorporates extensive research of reports and reviews by organizations such as EC, IEA, OECD, WEC. Research was also conducted in national reports and in national statistical organizations, especially with regards to the collection of public R&TD expenditure.

The difficult task of collecting private R&TD expenditure has been dealt with in a number of EU countries by assigning to consultants the development of strategic studies about the amount of money spent in R&TD by the main competitors in a specific sector.

Even if the major strength of this first solution is that it can provide useful information for very specific R&TD thematic areas as fuel cells and hydrogen, concerns regarding the data quality appear. In particular the following weaknesses emerged [14–16]:

- Many companies regard R&TD expenditure as property or strategic information. Thus, manipulation of the provided data appears to be affecting their quality. This is highly noticeable when there is no legal framework that defines the data type that private sector is obliged to provide.
- Companies agree to respond to the questionnaire only if the provided data are not up to date, thus these data is not considered of high importance, especially when there is the need to be used so as to design the public R&TD expenditure's policy.
- The strategic studies are not systematic, because they are often expensive and they provide only selected information that can not be used to build trends and long time series on private R&TD expenditure.

2.2. Financial data from collaborative R&TD programs

In some energy sectors such as transport and photovoltaic, a number of countries has built collaborative R&TD programs, where public funds finance one part of the R&TD projects and the remaining is financed by private firms. Generally the subsidy rate ranges from 30 to 50% and is publicly available [17].

In this situation, the steps followed to deduce public and private R&TD expenditure can be summarized as follows:

Step 1 *Research* for the specific R&TD funding programs and then distinction between the public and private beneficiary of the subsidy;
Step 2 *Calculation* of the average subsidy rate respectively for the public and private beneficiaries;
Step 3 *Deduction* of the estimated private and public expenditure generated by the public subsidy.

Good quality data concerning public and private R&TD expenditure can be collected; however, caution is needed since the private expenditure can be over or under estimated, depending on the choice made for the overheads' calculation. Therefore, the estimation of the overall companies' contribution to the total R&TD budget, by using financial statements of collaborative R&TD programs, is extremely difficult [18,19].

Moreover, it is not so easy to define the respective real annual R&TD expenditure, since the budget amount is defined for the whole project period (and not annually) and the precise time period of each project is not known or has not been published. However, apart from the above mentioned weaknesses, this solution can be useful to obtain an exact figure for public support to the R&TD work in question [20].

2.3. Investigation of annual activity reports

In countries where the energy sector includes very significant players, like in France with EdF and Total, in United Kingdom with BP or in Netherlands with Shell, the annual activity reports can be a useful source of data for private R&TD expenditure [21–23]. In particular the following steps have to be followed:

Step 1 *Company list.* At this stage, a large number of companies involved in R&TD activities can be listed. This list can be composed from data originating from official governmental and private organizations. During this procedure R&TD expenditure of each major R&TD player is listed.

Step 2 *Decomposition of each company's total R&TD expenditure.* At this phase of the research is realized the decomposition of each company's total expenditure. R&TD figures are collected, mainly by investigating each company's info. Annual reports are reviewed and tables are developed, placing emphasis on the separation and distribution of each company's expenditure to the appropriate sector of R&TD. Data can be cross-checked with total figures identified during the first phase. Informal exchange of information with people working in the firms' R&TD department could provide a rough picture of the budget percent spent in different sectors of energy technologies.

Step 3 *Composition of each category's total funding.* After separating each company's total R&TD funding and allocating it to the appropriate category, these figures are added. These collective figures are then added in order to formulate the overall picture of the R&TD expenditure per sector.

2.4. Partial R&TD financing

When private R&TD energy expenditure are not directly available, they can be estimated though the projects an organization participates in. More particularly, R&TD expenditure data can be gathered through the publications of DG RTD [24].

The major weakness of this solution is that it only permits obtaining partial information, as identified in a wide range of papers. Moreover, such information is also considered difficult to be found due to their sensitivity (strategic importance for the company undertaking the research).

3. The case of Greece

3.1. Data collection procedures

The data collection procedures followed for the collection of public R&TD expenditure in Greece incorporated all the approaches mentioned in Section 2. However, the approaches that provided the most reliable results and the largest data variety are the following:

- Specific study or assessment. Thorough and extensive research for annual studies, reports and reviews of international comparison in R&TD energy sector by international organisations was conducted. Detailed studies incorporating data and figures for public R&TD expenditure on different energy areas were found by IEA.
- Financial data from collaborative R&TD programs. Wide search in public R&TD institutes such as the General Secretariat for Research & Technology, CRES and Democritus for collaborative R&TD energy programs was realised. One of the difficulties encountered was that although the expenditure identified were public and private, the distinction between these two categories was inexistent and the data was registered as public. In this framework, personal contacts for data collection that can be helpful for the distinction between the public and private contribution of programs' budgets were realized.

The rest two approaches utilized did not return the expected results. The main reasons that are considered to have led to this outcome are:

The annual activity reports of energy companies in Greece are mostly related with RES and although some data can be found in such reports, it is unlikely to contain analytical information for all the requested fields of R&TD in the period 1990–2005. Moreover, due to the fact that the majority of these companies are at its initial development steps, while their size is considerably small, private R&TD expenditure data is usually difficult to track down, since there is no updated list with all involved actors.

Although contacts with unions of energy companies from different sectors (oil, gas, wind, solar, etc.) for the completion of information lists with all the companies that act in each sector were established, the results were poor, since these data are highly sensitive for the companies and therefore difficult to be gathered. In this context, personal visits at the facilities of each company for the completion of questionnaires regarding its R&TD expenditure in each related energy field and sector were realized, while our approach was conducted in a confidential and trustful way towards the companies in order the proper data to be accumulated.

3.2. Technology data categories

The variety of technology data categories, for which R&TD expenditure data were collected, are presented in Table 1. Their categorization follows the methodological approach presented above. In this context, in the table are clearly indicated the various technology categories, their subcategories and further potential disaggregation. Moreover, especially for Greece clarifications are provided whether the local data are available (A) in a disaggregated or aggregated form.

In this framework, the tabular overview of the data presents two distinct categories:

- Technologies where the disaggregation in their subcategories was not possible at the beginning, so as to have a common basis among all EU countries.

Table 1
Energy technologies' categories and expenditure' status in Greece

Energy technologies categories	Public	Private
Total fossil		
Total oil and gas		
Enhanced oil and gas production	A	
Refining transportation and storage of oil and gas	A	
Non-conventional oil and gas production	A	
Oil and gas combustion	Aggregated data only	
Oil and gas conversion		
Other oil and gas	A	
Total coal		
Coal prod. prep. and trans.	A	
Coal combustion	A	
Coal conversion (excl. IGCC)	A	
Other coal	A	
Total CO_2 capture and storage		
CO_2 capture/separation	Aggregated data only	
CO_2 transport		
CO_2 storage		
Total renewable energy sources		
Total solar energy		
Solar heating and cooling (incl. daylighting)	A	
Coal combustion	A	
Solar thermal power and high temp. apps	A	
Wind energy		
Disaggregation non possible	A	
Ocean energy		
Disaggregation non possible	A	
Bio-energy		
Production of transport biofuels incl. from wastes	Aggregated data only	
Production of other biomass-derived fuels incl. from wastes		
Applications for heat and electricity		
Other bio-energy (biodegradable fraction of municipal waste)		
Geothermal energy		
Disaggregation non possible	A	
Hydropower Energy		
Large hydropower (capacity >10 MW)	A	
Small hydropower (capacity <10 MW	A	
Total energy end—use efficiency		
Industry		
Disaggregation non possible	A	
Residential commercial (IEA)		
Disaggregation non possible	A	
Transportation		
Disaggregation non possible	A	
Total nuclear		
Total nuclear fission		
Light-water reactors (LWRs)	Aggregated data only	
Other converter reactors		
Fuel cycle		
Nuclear supporting technology		
Nuclear breeder		
Other nuclear fission		
Nuclear fusion		
Disaggregation non possible		

- Technologies, where although the disaggregation in their subcategories was possible, the data identified were in an aggregated form.

According to the above, disaggregation of the technology subcategories was not possible for the following technologies:

- Wind, ocean and geothermal energy;
- Industry, residential and commercial energy end use efficiency;
- Nuclear fusion.

On the other hand, only aggregated R&TD data were identified in the following categories:

- Oil and gas combustion and conversion;
- Total CO_2 capture and storage;
- Bioenergy;
- Nuclear fission.

3.3. Results–discussion

According to the above mentioned technology data categories and the existence or not of R&TD expenditure data in an aggregated or disaggregated form, below are presented two charts, where the allocation of Greek public and private expenditure data per technology category for the time period of 2000–2004 is clearly depicted (Figs. 1 and 2). At this point it should be noted that although the time period for which R&TD data were collected covers the last three decades, this 5 years period was selected since it was the only one for which data

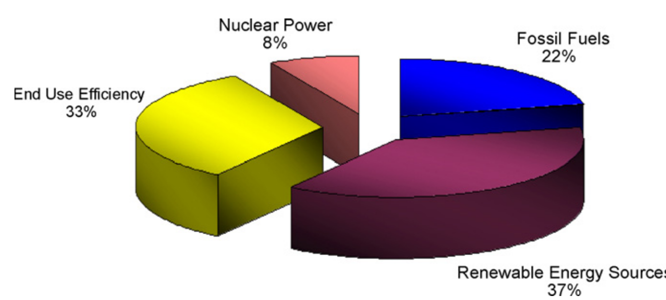

Fig. 1. Public R&TD expenditure distribution in the period 2000–2004.

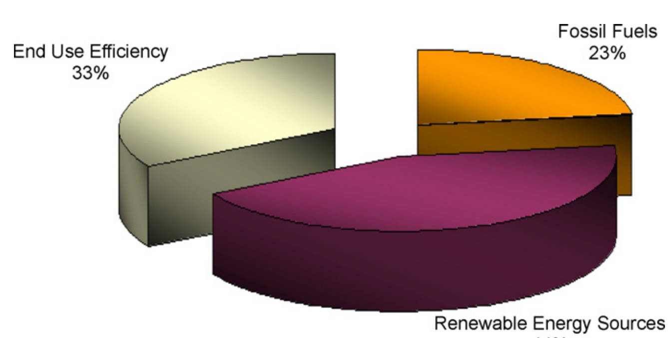

Fig. 2. Private R&TD expenditure distribution in the period 2000–2004.

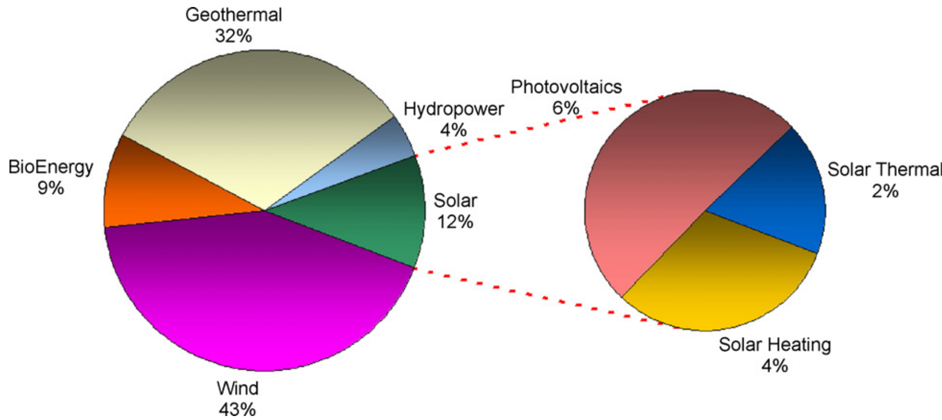

Fig. 3. R&TD expenditure distribution for RES in the period 2000–2004.

from both the private and the public sector were identified. Consequently, this choice was made so as to guarantee the quality of the conclusions, derived from their comparison.

One important point derived from these figures is that there are no private expenditure on nuclear power for Greece. This makes sense if someone considers that there are no nuclear power stations in Greece, and generally the use of nuclear power is only limited for laboratory test purposes. This fact is also enhanced from the Greek governmental energy policy, which does not encourage the use of nuclear power, partly due to the high frequency of earthquakes in Greece, thus consisting a very prohibiting factor for the development and safe operation of nuclear power stations.

On the other hand, it is clear that the private R&TD expenditure are mainly focused on the development of RES. Greece has a highly unexploited potential in RES and the EC directive 2001/77/EC on the promotion of electricity produced from RES has boosted the research on this technology category. However, even though the R&TD expenditure invested on these categories are significant, till now the penetration levels of RES electricity in the internal market are progressing slowly.

A clearer picture on the distribution of total, public and private, R&TD expenditure on RES technologies in Greece is provided in Fig. 3 below.

From Fig. 3 is clearly shown that the lion's share is placed on the wind and geothermal energy, while on the other hand the lowest percentage is met among hydropower and solar thermal technologies. This is in consistency with the existing situation of RES development in Greece.

Indeed, till now the largest part of RES produced electricity originates from the hydropower plants. It is estimated that the unexploited potential of hydropower electricity is extremely low for the country. Moreover, solar thermal power is a solution that greatly flourishes in the national reality, and therefore is a proven technology for the Greek conditions.

On the other hand, Greece possesses a significantly unexploited potential in the wind and geothermal energy. The significant R&TD expenditure offered in these technologies are an indirect way of promoting them.

4. Conclusions

A number of difficulties are associated with energy data collection, such as the double counting, the lack of reliable data disaggregated into energy technologies and thus the existence of data exclusively in their aggregated form. The different data collection strategies presented in this paper aimed to:

- Maintain a high level of data consistency, even if for the same topics and countries different source of data are used to rebuild R&TD expenditure time series.
- Qualify the data quality and avoid misinterpretation of the collected data.
- Improve the EU ability to follow the R&TD energy expenditure.

From the energy R&TD data collection procedures for the public and private sector, respectively, of the Greek energy market, the following points can be drawn:

- *Public ERTD Data*: Registration of funding for public energy R&TD is most of the times recorded as public expenditure no matter if the allocation is for use in the public or the private sector. Thus, in order to have the exact public expenditure, the contributions to the private sector have to be subtracted calculating the total research effort by adding expenditure of both sectors to obtain a total amount. Overhead expenditure at public institutions are sometimes not included in the statistical reporting for R&TD expenditure. In some cases, it is added only to the extent that the overhead is financed by external programme contributions. Moreover, periodicity difficulties in collecting and making use of data for expenditure both in the sense of public funding (for use in one or more years) and private expenditure (in a specific year) are dealt with in the same analysis. Doing so there appeared to be a big risk of double counting; this would provide on one hand wrong results and on the other hand problems with periodicity and time lag between funding and actual expenditure. It seems that a satisfactory solution to this problem may only be reached if the work and data recording is split into two analyses for funding and annual expenditure, respectively.

- *Private ERTD Data*: Company activity reports most of the times are of very low value for the purpose of obtaining reliable and detailed statistics on private energy R&TD expenditure since companies consider R&TD expenditure as sensitive data and of strategic importance. Data is not detailed enough and not split into categories of energy fields or technologies most of the times. Consistency in time series also occurred as in the case of public expenditure. R&TD expenditure is most of the times allocated for the whole project period and not separated in annual basis. Multinational companies in some cases do not split the R&TD figures between countries. This creates the uncertainty of allocating the data between countries and the breaking down of the expenditure on all energy subjects. Trans-national project coordination since in large multinational companies transparency is not easily obtained, especially when the R&TD funding is for large international projects through a nationally based coordinator. Old data concerning private R&TD although have been found, however, it is not of great use, as long as this data need to be analyzed by governmental institution to draft future private R&TD support programs.

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References

[1] European Commission. Action plan for energy efficiency: realizing the potential. COM(2006)545 final; October 19, 2006.
[2] European Commission. Green paper ‘‘Doing more with less’’. Luxemburg: European Communities; 2005.
[3] European Commission. An Energy Policy For Europe, COM (2007) 1 final; January 10, 2007.
[4] Doukas H, Mannsbart W, Patlitzianas KD, Psarras J, Ragwitz M, Schlomann B. A methodology for validating the renewable energy data in EU. Renew Energ 2007;32(12):1981–98.
[5] Doukas H, Papadopoulou AG, Psarras J, Ragwitz M, Schlomann B. Sustainable reference methodology for energy end-use efficiency data in the EU. Renew Sustain Energ Rev; in press. Available online at www.sciencedirect.com.
[6] European Commission. Energy for the future: renewable sources of energy—White Paper for a community strategy and action plan. COM (97) 599 final; November 26, 1997.
[7] European Commission. Towards a European strategy for energy supply security—Green Paper. COM (2000) 769 final; November 29, 2000.
[8] European Commission. Directive 2001/77/EC of the European Parliament and of the Council on the promotion of the electricity produced from renewable energy sources in the international electricity market; September 27, 2001.
[9] European Commission. Directive 2004/8/EC of the European Parliament and of the Council on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC; February 11, 2004.
[10] Runci PJ. Energy R&D in the European Union. USA: Battelle Memorial Institute—Pacific Northwest National Laboratory Operated for the U.S. Department of Energy; 1999.
[11] Vine E, Sathaye J. Guidelines for the monitoring, evaluation, reporting, verification, and certification of energy-efficiency projects for climate change mitigation. USA: Ernest Orlando Lawrence Berkeley National Laboratory; March 1999.
[12] Dooley JJ. Short primer on collecting and analyzing energy R&D statistics. USA: Battelle Memorial Institute—Pacific Northwest National Laboratory Operated for the U.S. Department of Energy; 2000.
[13] OECD. Frascati manual. Proposed standard practice for surveys on research and experimental development. OECD; 2002.
[14] OECD/IEA. Energy policies of IEA countries—review. OECD/IEA; 2000
[15] Eurostat. R&TD Questionnaires; 2001.
[16] International Energy Agency (IEA). Renewable energy: RD&D priorities—insights from IEA technology programmes. International Energy Agency (IEA); 2006.
[17] European Commission. REDS (Research & Development Spending: a survey of R&D spending for renewable energy in the EU countries): European research spending for renewable energy sources; 2004.
[18] International Energy Agency. Database on energy technology R&TD budgets. Available at www.iea.org.
[19] Priority Setting Initiative (Senser II). ‘‘Final Report’’; 2003.
[20] Hanekamp E, Larzeni S, Lorenzoni A, Marigo N, Miola A, Ragwitz M, Van Halen C. REDS: Research and Development Spending: a survey of RD&D spending for renewable energy in the EU countries. Project for DG Research in the fifth framework programme, ENK6-CT2002-80654; 2004.
[21] Runci PJ. Energy R&D in United Kingdom. USA: Battelle Memorial Institute—Pacific Northwest National Laboratory Operated for the U.S. Department of Energy; 2000.
[22] Luiten EEM, Blok K. Energy R&D in the Netherlands. Pacific Northwest National Laboratory, Battelle Memorial Institute; April 1999.
[23] Runci PJ. Energy R&D in Germany. USA: Battelle Memorial Institute—Pacific Northwest National Laboratory Operated for the U.S. Department of Energy; 1999.
[24] European Commission. Directorate-General for Research Sustainable Energy Systems. Brussels: Energy R&D Statistics in the European Research Area; 2005.